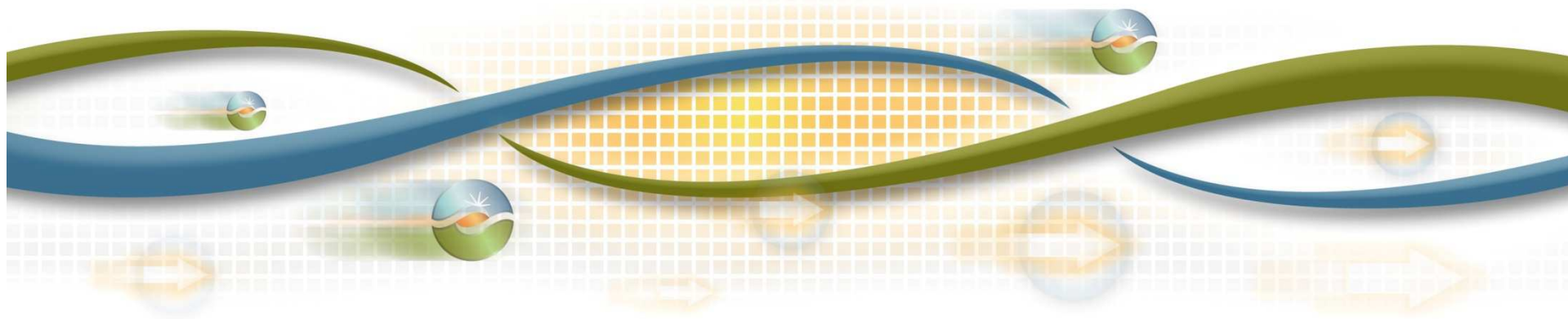


A Proposal for Stochastic Result Reporting Requirements

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A proposal for stochastic modeling result reporting requirements in the LTPP proceeding

- Proposal

To require submission of stochastic results in standard format in the California Public Utilities Commission (CPUC) Long-Term Procurement Plan (LTPP) proceeding filings

- Purposes

To support the CPUC in LTPP procurement decision making with sufficient and comparable information



Background

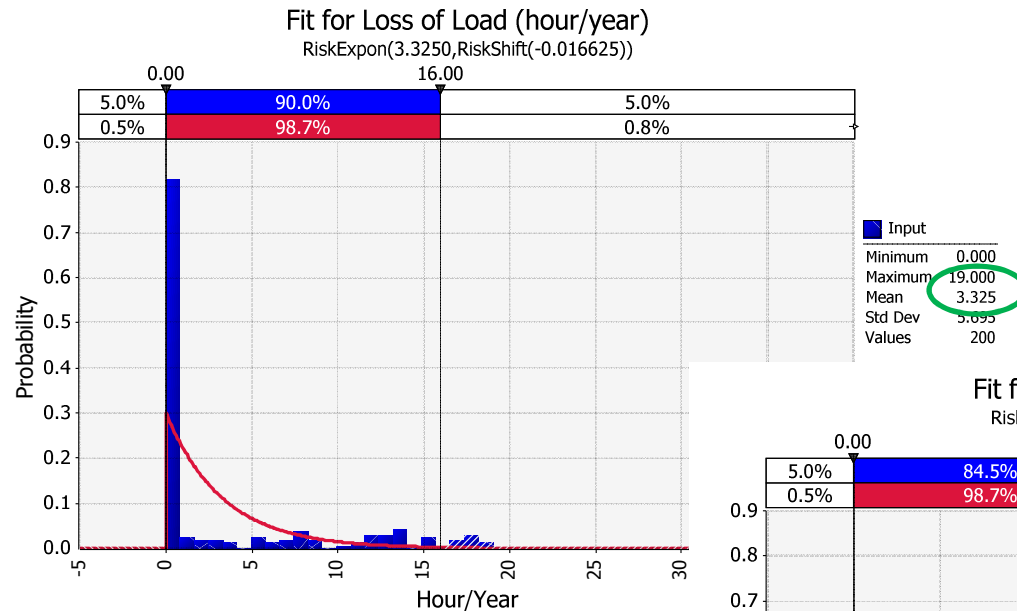
Stochastic modeling in LTPP is still developing.

- Diversified modeling methodologies
 - Development of stochastic variables
 - Availability of historical data
 - Discrete samples or distribution functions
 - Correlation among stochastic variables
 - Sampling of stochastic variable values
 - Sample pool sizes
 - Yearly or daily draws
 - Criteria
 - Security-based or value-based

Stochastic modeling in LTPP is still developing. (cont.)

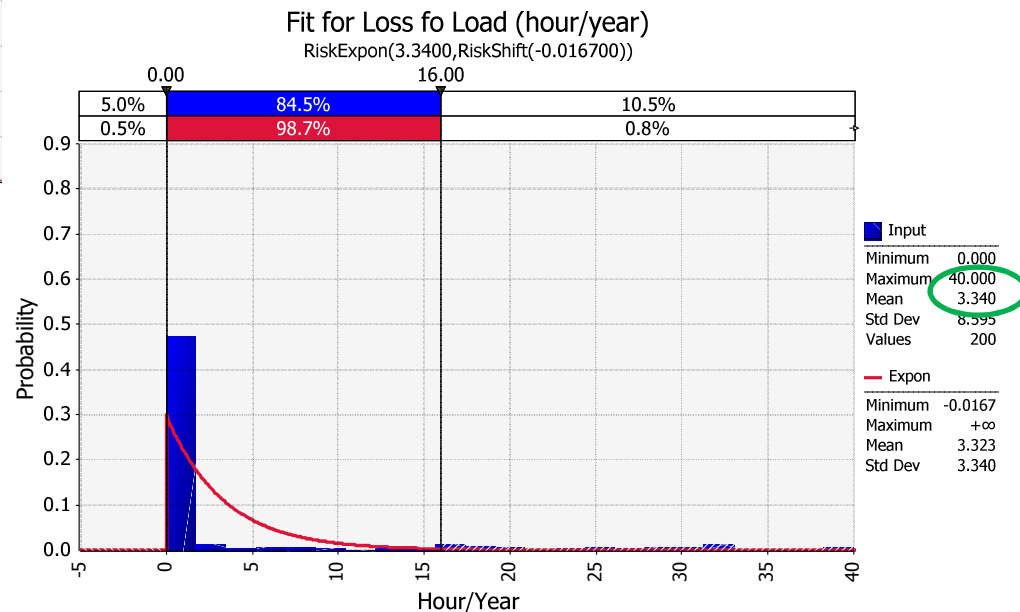
- Computing power limitation
 - Number of iterations in Monte Carlo simulations
 - Simulation horizons
- Large amount of data
 - Data generated in proportion to number of iterations
 - Difficult to review all the data in detail
- Limited simulation results reported
 - Most commonly Loss of Load Expectation (LOLE) and Loss of Energy Expectation (LOEE)

LOLE does not tell the whole story.



Similar LOLE but
significantly different
risk profile

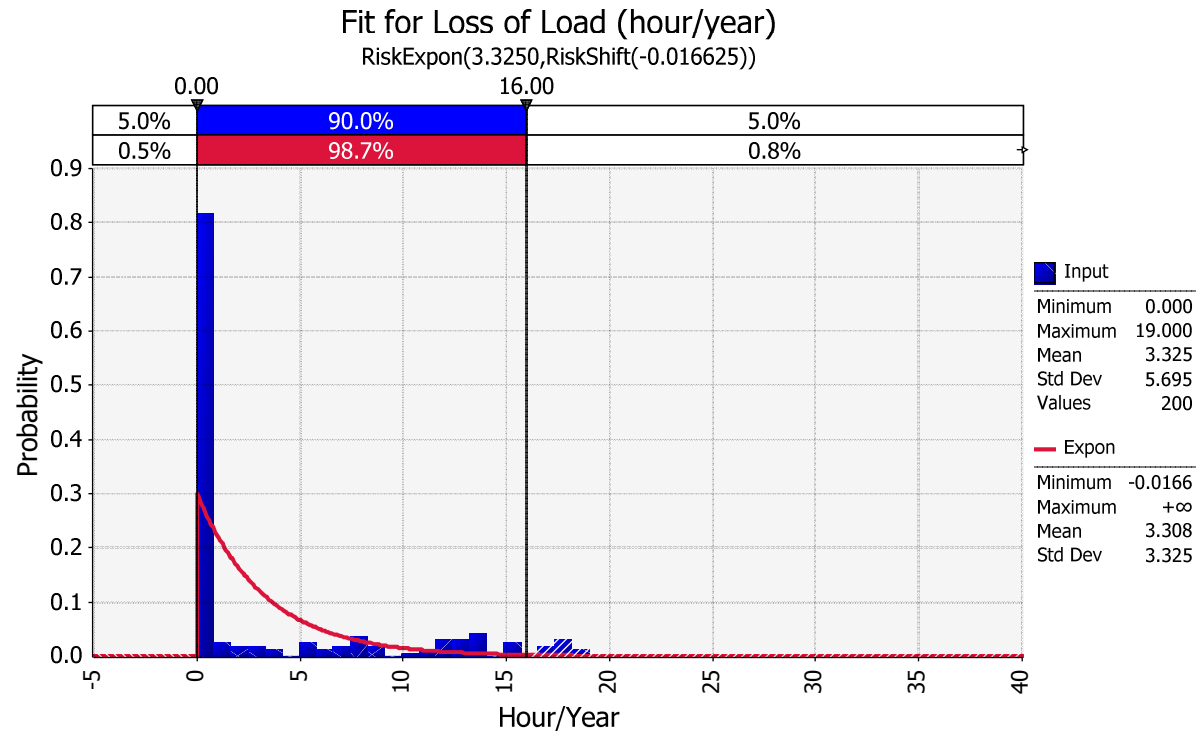
*Example data for illustration
purpose only.*



LOL is sensitive to model setups and executions.

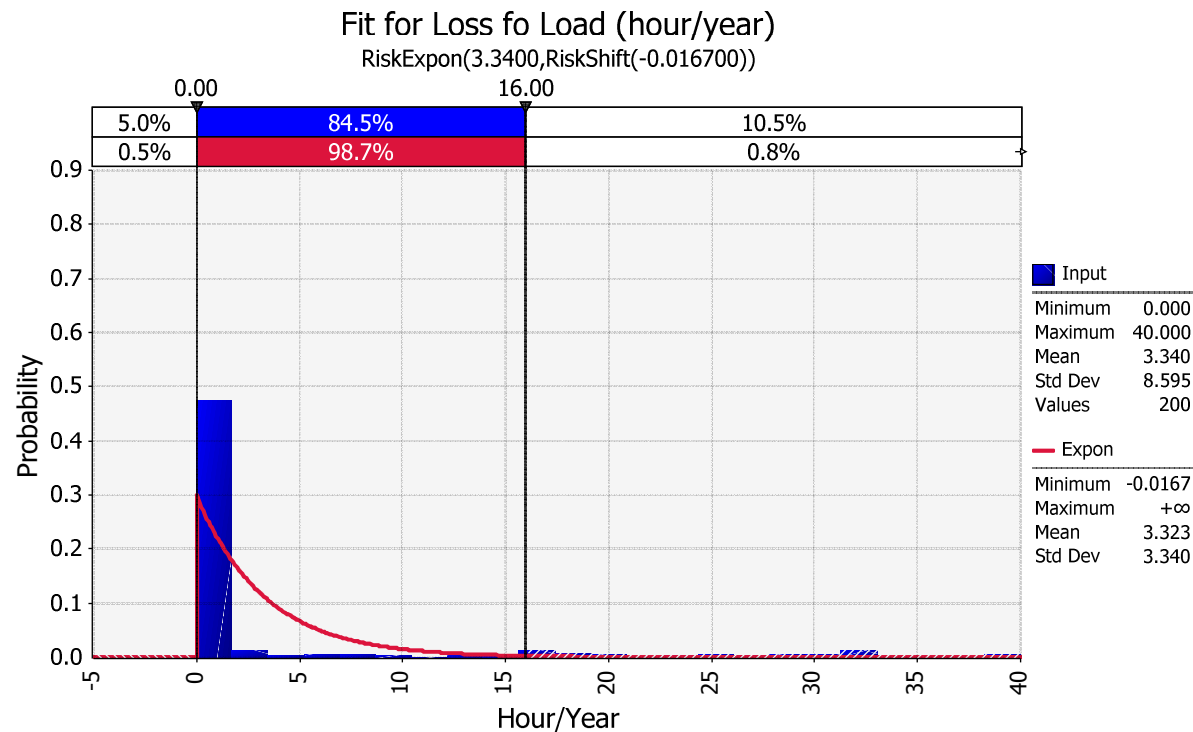
- Models are developed and executed based on
 - Best knowledge of the developers
 - Most accurate data available
 - Common and customized assumptions
 - Usable computing resources
- Simulation results vary with
 - Methodologies, data, and assumptions
 - Representation of extreme events
 - Curtailment of load and generation

More information helps understand the risks beyond that LOLE tells.



Category	50th Percentile	75th Percentile	80th Percentile	90th Percentile	95th Percentile	Min	Max	Mean (Expectation)	Standard Deviation	Total Number of Iterations	Number of Iterations with LOL
Loss of Load (LOL)											
- LOL (hour/year)	0	5	8	14	16	1	19	3.33	5.69	200	65

More information helps understand the risks beyond that LOLE tells. (cont.)



Category	50th Percentile	75th Percentile	80th Percentile	90th Percentile	95th Percentile	Min	Max	Mean (Expectation)	Standard Deviation	Total Number of Iterations	Number of Iterations with LOL
Loss of Load (LOL)											
- LOL (hour/year)	0	0	0	17	27	1	40	3.34	8.59	200	36



Proposed Reporting Requirements

More information about LOL, curtailment, and over-generation needs to be reported.

Required Information in Stochastic Simulation Result Reporting

Category	50th Percentile	75th Percentile	80th Percentile	90th Percentile	95th Percentile	Min	Max	Mean (Expectation)	Standard Deviation	Total Number of Iterations	Number of Iterations with LOL or Curtailment or Over-generation
Loss of Load (LOL)											
- LOL (hour/year)	0	5	8	14	16	1	19	3.33	5.69	200	65
- Loss of Energy (MWh/year)	0	237	341	624	707	42	885	149	257		
- LOL Capacity (MW)	0	57	57	58	58	41	58	16	24		
Loss of Load Due to Lack of Flexibility											
- LOL (hour/year)	0	0	0	2	5	1	10	0.64	1.96	200	26
- Loss of Energy (MWh/year)	0	0	0	68	199	32	437	23	72		
- LOL Capacity (MW)	0	0	0	45	57	32	58	5	14		
Curtailment of Renewable Generation											
- Curtailment (hour/year)	0	3	9	20	26	1	35	4.50	8.85	200	56
- Energy Curtailment (MWh/Year)	0	76	222	437	630	23	838	102	200		
- Capacity Curtailment (MW)	0	30	30	30	30	21	30	7	11		
Over-Generation											
- Over-Generation (hour/year)	0	0	0	9	14	1	21	1.75	4.49	200	36
- Over-Generation Energy (MWh/Year)	0	0	0	126	205	13	311	27	68		
- Over-Generation Capacity (MW)	0	0	0	24	24	13	24	3	8		

Clearly define what is a LOL event and describe what and how much ancillary services and other capacity reserves are maintained in a LOL event.

Definitions

- All raw data are collected by iteration from Monte Carlo simulations
- Each iteration simulation covers the whole year (or all the months or weeks in the year with LOL, renewable generation curtailment, or over-generation)
- For simulations with shorter horizon (e.g. drawing one day in an iteration) results should be converted to annual values (such as hours/year)

Definitions (cont.)

- “***Loss of Load (LOL)***” of an iteration is the total LOL of the year, including “***Loss of Load Due to Lack of Flexibility***” category
- “*LOL (hour/year)*” of an iteration is the total number of hours with LOL in the year
- “*Loss of Energy (MWh)*” of an iteration is the total LOE in the year
- “*LOL Capacity (MW)*” of an iteration is the maximum MW of LOL in a single hour in the year
- The definitions are similar for other categories

How to find the percentile values in the result by iteration?

- Sort the data from low to high by “*LOL (hour/year)*” (together with “*Iteration*”, “*Loss of Energy (MWh)*”, and “*LOL Capacity (MW)*”)
- Set “*Percentile Rank*” by column “*#*”
- Select the values of “*LOL (hour/year)*”, “*Loss of Energy (MWh)*”, and “*LOL (MW)*” matching 50%, 75%, etc. percentile ranks

- In the table some rows are hidden
- The “*#*” column has continuous numbers from 1 to 200 for setting “*Percentile Rank*” purpose

#	Percentile Rank	Iteration	LOL (hour/year)	Loss of Energy (MWh/year)	LOL Capacity (MW)
1		1	0	0.0	0.0
2		2	0	0.0	0.0
3		3	0	0.0	0.0
4		4	0	0.0	0.0
5		6	0	0.0	0.0
99		140	0	0.0	0.0
100	50%	144	0	0.0	0.0
101		146	0	0.0	0.0
149		89	5	230.6	52.6
150	75%	143	5	237.4	54.1
151		145	5	242.9	56.0
159		52	8	341.1	52.6
160	80%	198	8	341.2	43.6
161		70	8	350.0	52.5
179		142	14	567.1	49.1
180	90%	76	14	586.5	49.0
181		171	14	597.9	52.1
189		151	15	707.3	50.7
190	95%	181	16	673.1	45.4
191		73	17	734.8	52.9
200		87	19	885.0	47.8

About the 1 day-in-10 years LOLE standard*

- LOLE in days is evaluated using daily peak load values while LOLE in hours is obtained using hourly load values
- LOLE 1 day-in-10 years $\stackrel{?}{=}$ 24 hours-in-10 year
or 0.1 days/year $\stackrel{?}{=}$ 2.4 hours/year
- Some studies show 0.1 days/year is equivalent to 0.6~0.8 hours/year.
- 0.7 hours/year may be the standard to use until further more focused studies are conducted

* Reference - “Probability Fundamentals and Models in Generation and Bulk System Reliability Evaluation” by Roy Billinton , NERC workshop, Oct 16-18, 2013

Thank you!

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